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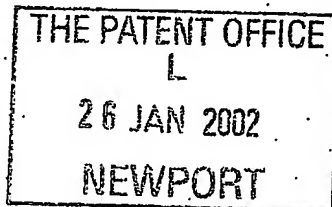
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# Request for grant of a patent

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1. Your reference

5409 88JAN02 E691242-1 D02651  
P01/7700 0.00-0201845.5

2. Patent application number

(The Patent Office will fill in this part)

0201845.5

26 JAN 2002

3. Full name, address and postcode of the or of each applicant (underline all surnames)

Renishaw plc  
New Mills  
Wotton-under-Edge  
Gloucestershire, GL12 8JR

Patents ADP number (if you know it)

2691002 /

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

Analogue Probe

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

E C Leland et al  
Renishaw plc, Patent Department  
New Mills  
Wotton-under-Edge  
Gloucestershire  
GL12 8JR

Patents ADP number (if you know it)

8187429001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country	Priority application number (if you know it)	Date of filing (day / month / year)
-	-	-

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing (day / month / year)
-	-

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

Yes

- a) any applicant named in part 3 is not an inventor, or
  - b) there is an inventor who is not named as an applicant, or
  - c) any named applicant is a corporate body.
- See note (d))

Patents Form 1/77

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Description 8

Claim(s) 0

Abstract 0

Drawing(s) 3 + 3

10. If you are also filing any of the following, state how many against each item.

Priority documents 0

Translations of priority documents 0

Statement of inventorship and right to grant of a patent (Patents Form 7/77) 0

Request for preliminary examination and search (Patents Form 9/77) 0

Request for substantive examination (Patents Form 10/77) 0

Any other documents (please specify) 0

11. I/We request the grant of a patent on the basis of this application.

Signature *R. L. L. L. L.* Date 25.01.2002

AGENT FOR THE APPLICANT

12. Name and daytime telephone number of person to contact in the United Kingdom A ILES 01453 524524

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# ANALOGUE PROBE

The present invention relates to an analogue probe with a stylus for contacting a workpiece.

5

Analogue probes are well-known and an example of a probe is described in our UK Patent No. 1,551,218. This patent describes a probe suspension mechanism which comprises three orthogonally arranged pairs of parallel springs connected in series between a fixed point on the probe housing and a movable member to which the workpiece-contacting stylus is connected. An analogue probe may be mounted on a coordinate positioning machine, for example a coordinate measuring machine, a machine tool or manually positionable measuring arm.

During a measuring operation on a workpiece using such a probe, a machine on which the probe is mounted is driven towards a workpiece to bring the stylus into contact with the workpiece. When the tip of the stylus contacts the workpiece the stylus will be deflected as the machine continues to move and measuring transducers within the probe generate outputs representing deflections of the probe stylus along three orthogonal axes. The outputs representing stylus deflection are combined with the machine outputs representing the position of the probe to give a true indication of the stylus tip position and therefore information about the surface of the workpiece. The term "analogue probe" refers to the fact that the outputs represent stylus deflection; in practice the outputs may be in digital form rather than analogue form.

Ideally it would be arranged that the axes of the probe are aligned with the coordinate axes of the machine when the probe is mounted on the machine so that the measuring deflections of the probe stylus will take place along the axes of the machine. However, such alignment is not always possible to achieve.

In addition there may be misalignment between the probe axes such that they are not orthogonal. Furthermore, the scaling factors of the true probe axes will in general deviate from their nominal values.

Therefore it is usual to calibrate the probe and machine system to determine the effects of any such misalignment and scaling error and thereafter to correct any measurements made on the workpiece for these effects.

To calibrate the probe it is desirable for the probe to have a datum position. This is a reference position in the travel of the stylus to which all the probe outputs refer. United States Patent 3,869,799 describes an analogue probe provided with a fixed mechanical geometrical zero point. Motors within the probe are used to secure the probe in X,Y and Z at the fixed mechanical geometrical zero point.

The use of motors to drive the probe into its mechanical geometrical zero point has the disadvantage that the size, weight, cost and control complexity of the probe are all increased.

The present invention provides an analogue probe for use in measuring apparatus comprising:

a housing,

a member movable with respect to the housing onto which a stylus may be mounted such that movement of the stylus results in movement of the member;

5       transducers which measure the relative movement of the member;

wherein when there is no stylus mounted on the member the member is biased into a precisely defined rest position with respect to the housing.

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The precisely defined rest position acts as a datum position for calibration of the probe and is a reference position to which all the probe outputs refer.

15

Preferably location means are provided to define the precisely defined rest position of the member. The location means may comprise at least one first location element on the member connectable with at least one  
20       second location element in a fixed position with respect to the probe housing.

One pair of location elements is sufficient to define the position of the member if the probe is the type  
25       which constrains rotation in the stylus (i.e. only permitting linear movement). Other types of probe may require further pairs of locating elements to restrain all the degrees of freedom of the member.

30       Preferably when the stylus is mounted on the member, the weight of the stylus holds the member away from the precisely defined rest position. Thus the member is only in the precisely defined rest position when the stylus is removed.

Preferably biasing means are provided to bias the member into the predetermined position. The strength of the biasing means is chosen with respect to the weight of the stylus such that the member is only urged  
5 into the precisely defined rest position whilst the stylus is not attached to the probe.

Preferably a damper is provided. This ensures that movement of the member into the predetermined position  
10 is smooth.

Preferably magnets are provided such that the locating elements of the locating means are urged together.

15 The present invention further provides a method of datuming said analogue probe, comprising the steps of:  
removing the stylus from the probe such that the member is biased into the precisely defined position with respect to the housing;  
20 and setting the datum values for the probe accordingly.

The datum value for the probe may be set by simple electronic control.

25

Preferred embodiments of the invention will now be described by way of example with reference to the accompanying drawings wherein:

Fig 1 shows an analogue probe with its stylus in  
30 contact with a workpiece;

Fig 2 shows a simplified internal view of the probe; and

Fig 3 shows the probe shown in Fig 2 with the stylus removed.

Fig 1 shows an analogue probe 8 mounted on the quill 2 of a coordinate measuring machine (not shown). A workpiece 6 to be measured is placed on the table or bed 4 of the coordinate measuring machine. The analogue probe 8 has a stylus 12 with a workpiece-contacting tip 14. The probe 8 is moved until the workpiece-contacting tip 14 of the stylus 12 comes into contact with the workpiece 6. The stylus is thus displaced (relative to the housing of the probe) to a position 11 shown by the dashed lines and the displacement of the stylus is measured by transducers inside the analogue probe. The outputs of these transducers are combined with the output of the coordinate measuring machine representing the position of the probe 8 to indicate the position of the workpiece-contacting tip 14 and thus the workpiece 6.

Fig 2 shows a simplified view of an analogue probe 8 of the invention which comprises a probe housing 10 and stylus 12. The stylus has a workpiece-contacting ball 14 at one end for touching the workpiece and the stylus is movable with respect to the probe housing 10.

The stylus 12 is de-mountable from the rest of the probe and may be removed and exchanged with other styli, for example it may be exchanged with styli of different lengths. The stylus is provided with a flange 16 which is connectable to a stylus mounting plate 18 of the probe. The stylus flange 16 and stylus mounting plate 18 may be held together magnetically and may be provided with kinetic elements to define the position of the stylus with respect to the stylus mounting plate 18 and ensure repeatability of location of the stylus.



The stylus mounting plate is attached to a central rod 20 inside the probe housing. The stylus 12 and rod 20 are rigidly connected so that the stylus 12 and rod 20 move together.

5

The probe may be of the type disclosed in UK Patent No. 1,551,218 in which three pairs of parallel springs restrict rotational movement of the rod 20 and stylus 12 and thus only allow translational movement.

10

Transducers are provided in the probe to measure the movement of the rod 20 with respect to the housing 10. For example, the rod 20 may be provided with optical scales 50 with corresponding optical readheads 52

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provided within the probe housing to measure displacement of the rod 10 and stylus 12 with respect to the housing 10. This is described further in European Patent No. 0568120.

20

A locating element comprising a ball 22 is provided on the rod 20 and a corresponding locating element comprising a recess 24 is located at a fixed position within the probe housing 10. The recess may, for example, be tri-hedral or conical. The rod 20 may be

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pushed upwards so that the ball 22 engages with the recess 24. When the ball 22 and recess 24 are in engagement the position of the rod 20 is thus defined.

30

The ball and recess define the position of the rod 20 in three linear degrees of freedom. In the type of analogue probe in which the rod 20 is constrained from angular motion no further restraint is necessary. However a probe in which angular movement of the rod is not constrained requires further connecting pairs of elements, for example three pairs of elements will

provide the support which constrains all degrees of freedom. The rod is thus constrained kinematically.

The present embodiment discloses ball and recess  
5 locating elements, however other locating means may be used. In this embodiment the ball and recess may be on either the rod 20 or the fixed surface.

As shown in Fig 2 if the stylus 12 is connected to the  
10 rod 20, the weight of the stylus 12 pulls the rod 20 away from the reference position. However, as shown in Fig 3, if the stylus is removed from the probe the rod  
20 is biased into the reference position.

15 A spring 26 is provided to bias the rod 20 into the reference position. Figs 2 and 3 show a compression spring 26 with one end of the spring connected to a surface 25 which is connected to the stylus mounting plate 18 and the other end to a surface 27 within the  
20 probe. Alternatively the spring may comprise a tension spring which may, for example, be connected between the stylus mounting plate 18 and a fixed surface within the probe. If a stylus 12 is attached to the rod 20, the weight of the stylus will counterbalance the spring 26  
25 and the rod 20 will therefore not be pulled into the reference position. In the event of the stylus 12 being removed from the probe the rod 20 will be pulled into the reference position by the spring 26.

30 Magnets 30,31 are provided which attract the rod 20 into the reference position once it is almost in position (and the magnets are close together). The magnets also hold the rod 20 in this reference position. Figs 2 and 3 show magnets 30,31 located on

the stylus mounting plate 18 and on a surface 32 within the probe housing. The magnets may have alternative locations, for example adjacent the locating elements.

- 5 A damper 34 is provided to ensure that the movement of the rod 20 to its reference position is smooth and uncontrolled shocks to the probe are eliminated. This is particularly important if the probe transducers comprise optical scales and readheads as these are  
10 particularly sensitive. The damper ensures smooth movement and thus repeatability.

The probe has the advantage that it returns to its reference position whenever the stylus is removed with  
15 no manual intervention required. As the probe is biased into this reference position no control lines are required (i.e. as would be required if the process was motorised), thus the probe controller is only required to read output from the probe.

20

When the probe is mounted on a coordinate measuring machine and calibrated the probe is automatically in its datum position. This datum position acts as a reference point to which the probe outputs refer.

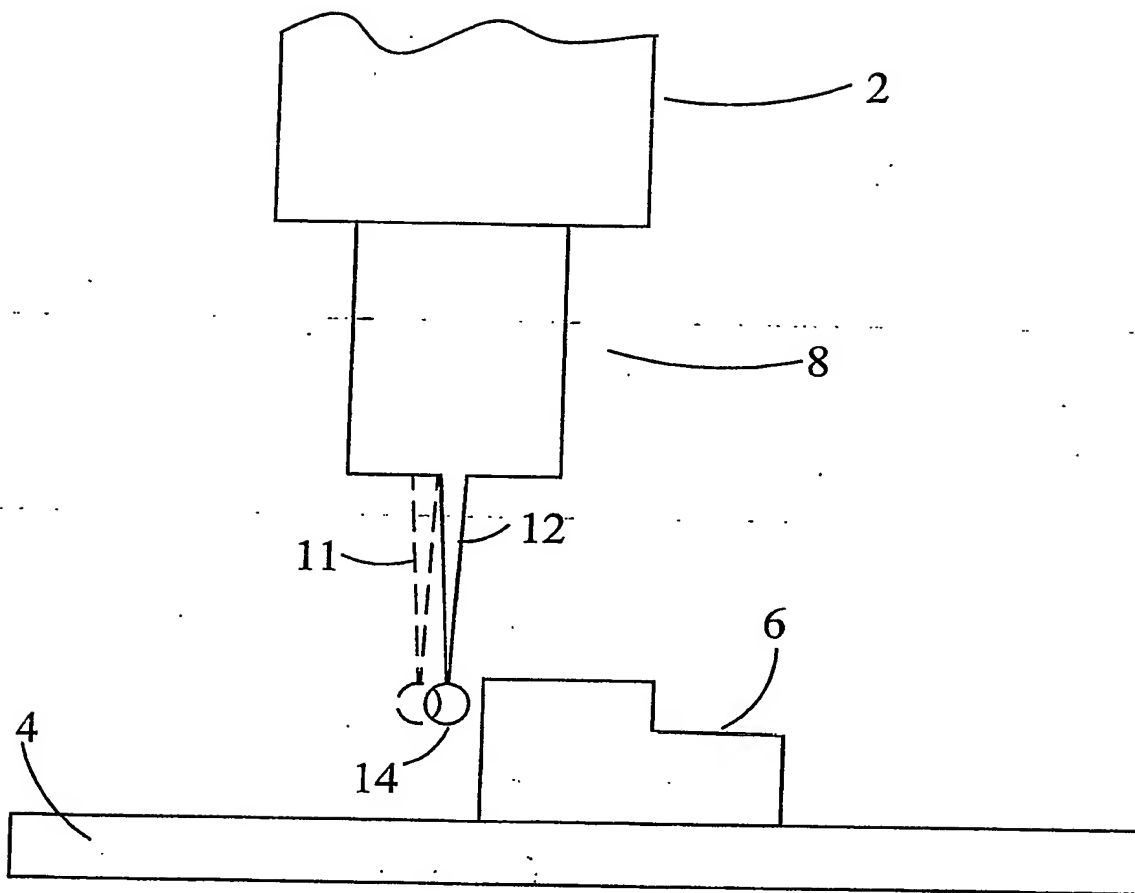


Fig 1

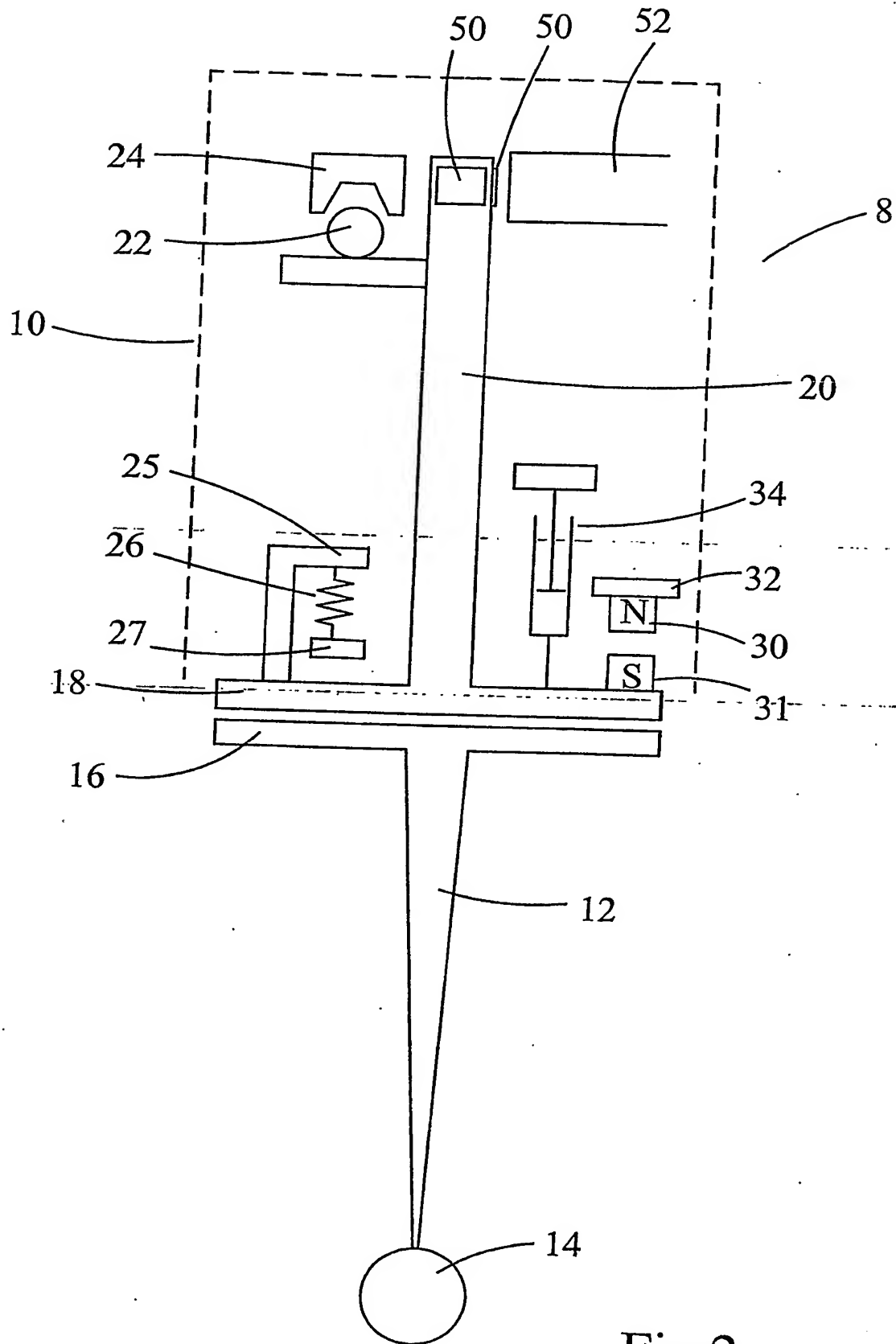


Fig 2

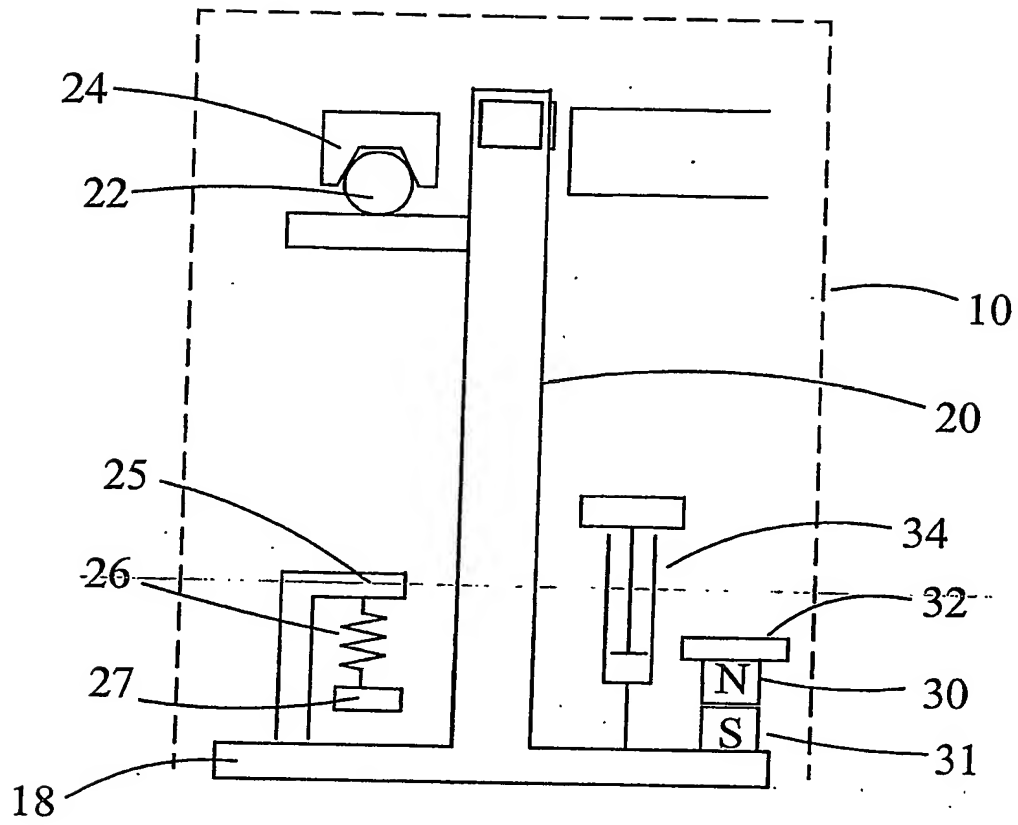
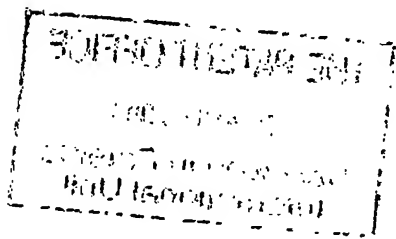


Fig 3



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